Chapter 14

Primary Zinc Processing

For purposes of this report, the primary zinc processing sector consists of one facility that, as of September 1989, was the only active zinc facility using pyrometallurgical (smelting) techniques and reported generating a special waste from mineral processing: slag from primary zinc processing. Three additional facilities are also primary producers of zinc. These facilities, however, use electrolytic production techniques that do not generate any special wastes, that is, the wastes from electrolytic productions are no longer Bevill excluded wastes.[1] Therefore, the primary electrolytic processors' operations are not discussed in this report. The information included in this section is discussed in additional detail in a technical background document in the supporting public docket for this report.

14.1 Industry Overview

Zinc metal is used in many applications, primarily in the construction, transportation, machinery, electrical, and chemical industries. The predominant use is for galvanizing and electrogalvanizing; other applications include manufacture of brass, bronze, zinc-based alloys, and rolled zinc. Zinc oxide is the most widely used compound of zinc, and is used both for its light-sensitive characteristics and as a starting material in the production of other zinc chemicals.[2]

The sole pyrometallurgical zinc production facility in the U.S. is located in Monaca, Pennsylvania. The facility is operated by Zinc Corporation of America (ZCA); that company is in turn owned by Horsehead Industries, headquartered in New York City. The facility initiated operations in 1936 and was modernized in 1980, at which time four electrothermic furnaces began operation. The facility's 1988 annual capacity, based on a 366 day year, was 101,300 metric tons of zinc. In 1988, the annual capacity utilization rate was 98.5 percent, based on total 1988 reported production of 99,800 metric tons of zinc.[3]

In 1989, zinc consumption increased in the Western World (i.e., the world market not including Eastern European countries) for the seventh consecutive year. A major force in zinc's performance has been the strong demand from the automobile industry for galvanized sheet metal. Galvanizing accounted for 45 percent of zinc consumption in 1989, followed by brass manufacturing at 20 percent and die casting at 15 percent. While zinc demand is likely to stabilize in 1990, due to a slowdown in North America, it is expected to rise again in 1991.[4]

Because of the steadily increasing demand for galvanized sheet metal - the healthy growth trend for zinc witnessed in the 1980's is likely to continue into the 1990's. In 1989, U.S. production of mined zinc rose by 17 percent, to 300,000 metric tons; this marked the third straight year that production rose, owing to the startup of six new and reopened mines.[5] By 1991, U.S. mine production of zinc could double that of 1989 due, primarily, to the huge Red Dog, Alaska mine, which opened in November 1989.[6] However, increased domestic zinc mining is not expected to raise U.S. metal production, because most new mine output is scheduled for export because of a lack of zinc smelting capacity in the United States.[7]

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[1] In addition to the primary facilities, as many as ten secondary facilities may be operating; the operations conducted at these facilities, however, fall outside the definition of primary mineral processing and, accordingly, do not generate special mineral processing wastes.

[2] Bureau of Mines, 1985. Mineral Facts and Problems, 1985 Ed., p. 929.

[3] Zinc Corporation of America, 1989(a). Response to "National Survey of Solid Wastes from Mineral Processing Facilities", 1989.

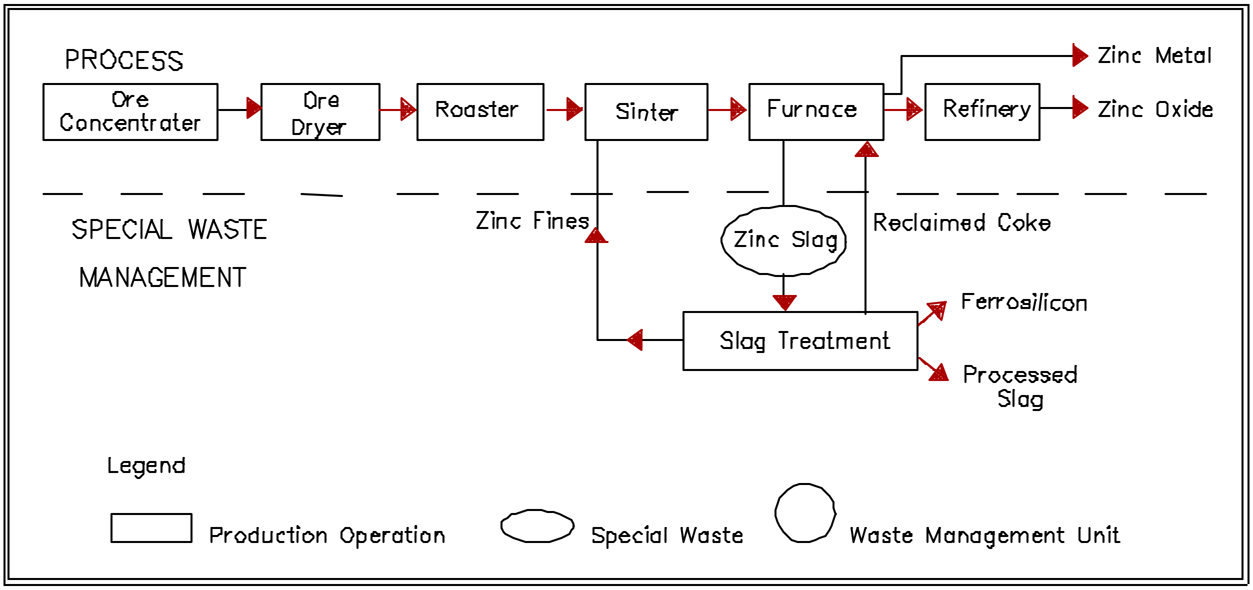
[4] Edward M. Yates, "Zinc: Prices Top Out in 1989," E&MJ, March 1990, p. 20-22.

[5] Ibid.

[6] James H. Jolly, U.S. Bureau of Mines, Mineral Commodity Summaries, 1990 Ed., p. 191.

[7] Ibid.

Exhibit 14-1
Pyrometallurgical Primary Zinc Processing



While primary zinc slab production has remained relatively flat in the late 1980's (up only 1.5 percent since 1985, from 261,000 metric tons to 265,000 metric tons), secondary zinc slab production has shown a strong increase, up 51 percent since 1985 from 73,000 metric tons to 110,000 metric tons. Another trend evident in the late 1980's and likely to continue in the near future is the use of electrolytic zinc smelting techniques. During the 1980's the zinc industry has moved steadily away from pyrometallurgical smelting operations to the more energy efficient, cost effective electrolytic smelting operations. Only one primary pyrometallurgical zinc smelting facility -- the Monaca, Pennsylvania that is described in this chapter -- is currently operating in the United States. Any new zinc slab primary processing capacity, developed to meet increased demand for zinc, will likely come from electrolytic facilities rather than pyrometallurgical facilities. However, because of its ability to process secondary materials, the Monaca facility is likely to be able to maintain its market position for the forseeable future.

In the smelting process, zinc is vaporized from sintered calcine in retort furnaces and then condensed and recovered (see Exhibit 14-1).[8] At the Monaca facility, medium to high grade sulfide concentrates are roasted and sintered in preparation for retorting. Significant quantities of high-grade calcine extracted from electric air furnace (EAF) dust and other secondary materials (e.g., skimmings and drosses) that are not as readily recoverable in electrolytic zinc plants are used to supplement the ore concentrate feed.[9,10] The ore concentrate and secondary feed values are charged along with an equal volume of coke into the top of one of four vertical shaft electrothermic furnaces.[11] Electric current, supplied from a company owned coal-fired power plant, flows through the charge, supplying the energy required for the reduction reaction through resistance heating. Zinc vapor from the retorts passes into distillation columns in the refinery where the purified zinc vapor is collected as a liquid metal and cast into metal or processed into various products. A solid residue remains behind in the retort furnace; this is the zinc slag that is the special waste.

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[8] Marks, 1978. Encyclopedia of Chemical Technology, Marks, et al., editors; Wiley Interscience, New York, NY, 1978; p. 827.

[9] James H. Jolly, 1990. Personal communication, June 27, 1990.

[10] Weiss, 1985. SME Mineral Processing Handbook, Weiss, N.L., editor; Society of Mining Engineers, NY, NY, 1985; pp. 15:11-12.

[11] Zinc Corporation of America, 1989(b). Public comments from Zinc Corporation of America addressing the 1989 proposed Reinterpretation of the Mining Waste Exclusion (Docket No. -- MWRP00073); May 30, 1989; Appendix A.

14.2 Waste Characteristics, Generation, and Current Management Practices[12]

The zinc slag that is removed from the furnaces is a rock-like solid material (pieces range in size from three inches to a foot in diameter) composed primarily of iron, silicon, and unreacted coke. Non-confidential waste generation rate data were reported for this material by the ZCA. The generation of furnace slag was approximately 157,000 metric tons in 1988, thus, the 1988 waste-to-product ratio was 1.6 metric tons of slag to each metric ton of zinc product.

At the Monaca facility, the slag from the furnace goes directly to one of two crushers while it is still red hot. A series of crushing/separation operations are employed to separate the slag into the four material streams shown in Exhibit 14-2.

The fines and coke are recycled to beneficiation and processing operations at the facility. On the other hand, the processed slag is stored in slag waste piles, disposed in a flyash landfill, or sold for such uses as road gravel or construction aggregate, while the ferrosilicon is accumulated in a stockpile until it can be sold. The processed slag is (ranging in size from approximately 1.3 cm to 6.4 cm (0.5 to 2.5 inches) accumulated in the storage piles (some of which is subsequently used as road gravel or in the flyash landfill), while the ferrosilicon pile contains particles that are typically about 0.64 cm in size.

Of the 157,000 metric tons of total raw zinc slag generated at the zinc processing facility in 1988, 28,000 metric tons and 17,000 metric tons were separated out as processed slag and ferrosilicon, respectively. The ferrosilicon is accumulated in a pile that is approximately 7 meters high and has a basal area of 8,000 square meters (2 acres). The processed slag pile (in several adjacent piles) covers an area of about 1.2 hectares and is roughly 7 meters in height. In addition, slag has been placed in a layer at the bottom of the facility's flyash landfill that is approximately 0.3 meters (1 foot) deep and covers an area of about 8 hectares. Slag has also been used as gravel on parking lots and other areas of the plant site. As of 1988, the quantities of waste accumulated in the ferrosilicon pile, processed slag pile, and the landfill were roughly 48,000, 63,500, and 45,400 metric tons, respectively.

Using available data on the composition of zinc slag, processed slag, and ferrosilicon, EPA evaluated whether any of these materials exhibit any of the four hazardous waste characteristics: corrosivity, reactivity, ignitability, and extraction procedure (EP) toxicity. Based on available information and professional judgment, EPA does not believe that any of the three materials are corrosive, reactive, or ignitable; however, samples of all three frequently exhibit the characteristic of EP toxicity based on the lead content, as shown below.

- Generated Slag. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for one sample of zinc slag from the Monaca facility. Of these constituents, only lead was found to exceed the EP toxicity regulatory level, by a factor of 12. The zinc slag sample that failed the EP toxic level was also analyzed using the SPLP leach test; this test indicates that the lead concentration was three orders of magnitude below the EP toxic level.

[12] All responses, unless noted are from the response of Zinc Corporation of America to EPA's "National Survey of Solid Wastes from Mineral Processing Facilities", conducted in 1989.

Exhibit 14-2

Primary Management of Zinc Slag

Residual Stream	Quantity (mt/yr)	Residual Management
Zinc fines	79,000	Returned to Sinter Plant
Reclaimed Coke	33,000	Recycled to Retort Furnace
Processed Slag	28,000	Disposed
Ferrosilicon	17,000	Stockpiled

- Processed Slag. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for 36 samples of processed slag from the Monaca facility. Of these constituents, only lead was found to exhibit the characteristic of EP toxicity for lead in 25 samples by as much as a factor of 12.8. One of the processed zinc slag samples that exhibited the characteristic of EP toxicity was also analyzed using the SPLP leach test; these data indicate that the concentration of lead measure exhibited the characteristic of using the SPLP leach test was roughly three orders of magnitude below the EP toxic regulatory level.

- Ferrosilicon. EP leach test concentrations of all eight inorganic constituents with EP toxicity regulatory levels are available for one sample of ferrosilicon from the Monaca facility. The only constituent detected in the ferrosilicon in a concentration that exceeds the EP level was lead (it exceeded the EP level by a factor of almost 10). The ferrosilicon sample that failed the EP toxic level was also analyzed using the SPLP leach test; the resulting concentration of lead was three orders of magnitude below the EP toxic levels.

14.3 Potential and Documented Danger to Human Health and the Environment

This section addresses two of the study factors required by §8002(p) of RCRA: (1) potential danger (i.e., risk) to human health and the environment; and (2) documented cases in which danger to human health or the environment has been proven. Overall conclusions about the hazards associated with zinc slag are provided after these two study factors are discussed.

14.3.1 Risks Associated With Processed Zinc Slag and Ferrosilicon

Because two of the four material streams arising from zinc slag processing are recycled directly to the production process without any potential contact with the environment, EPA's risk analysis of primary zinc slag is limited to an examination of the processed slag and the ferrosilicon. Any potential danger to human health and the environment from these two wastes is a function primarily of the composition of these materials, the management practices that are applied to them, and the environmental setting of the facility where the processed zinc slag and ferrosilicon are generated and managed. These factors are discussed separately below for each material, followed by EPA's risk modeling results.

Constituents of Potential Concern in Processed Zinc Slag

EPA identified chemical constituents in the processed zinc slag (as managed) that may pose a risk by collecting data on the composition of slag from the Zinc Corporation of America facility in Monaca, and evaluating the intrinsic hazard of the chemical constituents present in the slag.

Data on Processed Zinc Slag Composition

EPA's characterization of processed zinc slag and its leachate is based on data from two sources: (1) a 1989 sampling and analysis effort by EPA's Office of Solid Waste (OSW); and (2) industry responses to a RCRA §3007 request in 1989. (The §3007 data provided only results of EP leach test analyses.) These data provide information on the concentrations of 19 metals and chloride in total solids and leach test analyses. Concentrations of most constituents from leach test analyses of the processed zinc slag generally are consistent across the data sources and types of leach tests (i.e., EP and SPLP). EP leach test concentrations of zinc, however, were approximately four orders of magnitude higher than zinc concentrations in SPLP leach test analyses.

Process for Identifying Constituents of Potential Concern

As discussed in detail in Section 2.2.2, the Agency evaluated the zinc slag data to determine if the slag or slag leachate contain any chemical constituents that could pose an intrinsic hazard, and to narrow the focus of the risk assessment. The Agency performed this evaluation by first comparing constituent concentrations to conservative screening criteria and then by evaluating the environmental persistence and mobility of any constituents present in concentrations above the criteria. These screening criteria are conservative because they were developed using assumed scenarios that are likely to overestimate the extent to which the zinc slag constituents are released to the environment and migrate to possible exposure points. As a result, this process identifies and eliminates from further consideration those constituents that clearly do not pose a risk.

The Agency used three categories of screening criteria that reflect the potential for hazards to human health, aquatic ecosystems, and water resources (see Exhibit 2-3). Given the conservative nature (i.e., overly protective) nature of these screening criteria, contaminant concentrations in excess of the criteria should not, in isolation, be interpreted as proof of hazard. Instead, exceedances of the criteria indicate the need to evaluate the potential hazards of the slag in greater detail.

Identified Constituents of Potential Concern

Exhibits 14-3 and 14-4 present the results of the comparisons for zinc slag solid and leach test analyses, respectively, to the screening criteria described above. These exhibits list all constituents for which sample concentrations exceed a screening criterion.

Of the 20 constituents analyzed in the zinc slag solids, only chromium, lead, nickel, and selenium are present at concentrations exceeding the screening criteria (see Exhibit 14-3). These four metals were detected in all samples analyzed, but based on the frequency and magnitude of their concentrations exceeding the screening criteria, chromium and lead are of greater potential concern. Chromium exceeded the inhalation criterion by as much as a factor of 13 and lead exceeded the ingestion criterion by a factor of 6; nickel and selenium exceeded the criteria by a factor of roughly 1.2. All of these constituents are persistent in the environment (i.e., they do not degrade).

Exhibit 14-3
Potential Constituents of Concern in Zinc Slag Solids[a]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Human Health Screening Criteria[b]	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Chromium	2 / 2	Inhalation*	2 / 2
Lead	2 / 2	Ingestion	1 / 2
Nickel	2 / 2	Inhalation*	1 / 2
Selenium	2 / 2	Inhalation	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

These exceedances of the screening criteria indicate the potential for two types of adverse effects, as follows:

- Lead concentrations in processed zinc slag may cause adverse health effects if a small quantity of zinc slag or soil contaminated with the slag is inadvertently ingested on a routine basis (e.g., if children playing on abandoned waste piles or driveways made from slag were to inadvertently ingest the slag).

- Chromium, and to a lesser extent, nickel and selenium concentrations exceed the health-based screening criteria for inhalation. Thus, chromium and nickel could pose a cancer risk (i.e., greater than $1x10^{-5}$) while selenium could cause adverse noncancer effects if slag dust is blown into the air and is inhaled in a concentration that equals or exceeds the National Ambient Air Quality Standard for particulate matter. However, as discussed in a following section, the Agency does not expect such large releases and exposures because the vast majority of the waste slag exists as particles too large to be suspended, transported, or respired. It is likely that only a very small fraction of the slag will be weathered and aged (or crushed) into smaller particles that can be suspended in air and cause airborne releases and related impacts.

Based on a comparison of leach test concentrations of 20 constituents to surface and ground-water pathway screening criteria (see Exhibit 14-4), nine constituents (lead, manganese, zinc, copper, cadmium, nickel, arsenic, selenium, and iron) are present in concentrations that occasionally exceed the criteria. Of these constituents, lead, manganese, zinc, and copper appear to present the greater potential hazard because their concentrations in all samples analyzed exceed at least one screening criterion. Only lead, manganese, zinc, and arsenic exceeded the screening criteria by a factor of 10 or more, and only lead was detected in concentrations above the EP toxicity regulatory level. All of these constituents are inorganics that do not degrade in the environment.

Exhibit 14-4

Potential Constituents of Concern in Zinc Slag Leachate[(a)]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Screening Criteria[(b)]	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Lead	35 / 35	Human Health Resource Damage Aquatic Ecological	34 / 35 35 / 35 34 / 35
Manganese	2 / 2	Resource Damage	2 / 2
Zinc	2 / 2	Human Health Resource Damage Aquatic Ecological	2 / 2 2 / 2 2 / 2
Copper	2 / 2	Aquatic Ecological	2 / 2
Cadmium	29 / 34	Human Health Resource Damage Aquatic Ecological	1 / 34 4 / 34 4 / 34
Nickel	2 / 2	Resource Damage Aquatic Ecological	1 / 2 2 / 2
Arsenic	2 / 26	Human Health*	2 / 26
Selenium	1 / 24	Resource Damage	1 / 24
Iron	2 / 2	Resource Damage	1 / 2

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

(b) Human health screening criteria are based on exposure via incidental ingestion and inhalation. Human health effects include cancer risk and noncancer health effects. Screening criteria noted with an "*" are based on a $1x10^{-5}$ lifetime cancer risk; others are based on noncancer effects.

These exceedances of the screening criteria indicate the potential for the following types of impacts under the following conditions:

- If the slag leachate is released and diluted by only a factor of 10 during migration to a drinking water supply, concentrations of lead, zinc, cadmium, and arsenic in zinc could cause adverse health effects from the long-term chronic ingestion of untreated drinking water. The diluted concentration of arsenic could pose a cancer risk of greater than $1x10^{-5}$ from drinking water exposures.
- Concentrations of lead, zinc, copper, cadmium, and nickel in zinc slag leachate could threaten aquatic organisms if the leachate enters surface water and is diluted by a factor of 100.
- If released to ground water or surface water and diluted by a factor of 10 or less during migration, lead, manganese, zinc, cadmium, nickel, selenium, and iron concentrations in zinc slag

leachate potentially could exceed drinking water maximum contaminant levels or irrigation guidelines.

These exceedances of the screening criteria, by themselves, do not demonstrate that zinc slag poses a significant risk, but rather indicate that the slag could pose a risk under a very conservative, hypothetical set of release, transport, and exposure conditions. To determine the potential for the slag to cause significant impacts, EPA analyzed the actual conditions that exist at the facility that generates and manages the waste (see the following section on release, transport, and exposure potential).

Constituents of Potential Concern in Ferrosilicon

Using the same process summarized for processed slag, EPA identified chemical constituents in the ferrosilicon that may pose a risk by collecting data on the composition of this material from the Monaca facility, and evaluating the intrinsic hazard of the chemical constituents present in the ferrosilicon.

Data on Ferrosilicon Composition

EPA's characterization of ferrosilicon and its leachate is based on data from OSW's 1989 sampling and analysis effort. These data provide the concentrations of 18 metals in total solids and leach test (both EP and SPLP) analyses, and represent samples of the ferrosilicon as it is managed at the Monaca plant.

Concentrations of most constituents from leach test analyses of the ferrosilicon generally are consistent across the two types of leach tests. EP leach test concentrations of zinc and lead, however, were almost three orders of magnitude higher than the concentrations of these metals in SPLP leach test analyses.

Identified Constituents of Potential Concern

As in the zinc slag, only chromium, lead, nickel, and selenium are present in the ferrosilicon at concentrations exceeding the screening criteria. Although the concentrations of all four of these constituents exceed screening criteria in all samples analyzed, lead and chromium exceed the criteria by the widest margin (lead exceeds by a factor of 20 and chromium exceeds by a factor of 9; nickel and selenium exceed by a factor of 4 or less). Just like the slag, lead concentrations in ferrosilicon exceed the screening criterion for ingestion, while chromium, and to a lesser extent, nickel and selenium concentrations exceed the health-based screening criteria for inhalation.

Based on a comparison of leach test concentrations for the 18 constituents to the surface and ground-water pathways screening criteria (see Exhibit 14-5), seven metals (lead, manganese, copper, nickel, zinc, selenium, and iron) were detected at levels above the screening criteria. Concentrations of these metals in all samples analyzed exceed at least one screening criterion. However, lead, manganese, and copper exceed the screening criteria by the widest margins. Lead exceeds by as much as a factor of 970, and copper and manganese exceed by factors of 24 and 30, respectively. The concentrations of the other constituents exceed the screening criteria by less than a factor of 10. Only lead was detected in a concentration that exceeds the EP toxicity regulatory level.

These exceedances indicate the potential for three types of impacts, as follows:

- Concentrations of lead and nickel in ferrosilicon leachate could cause adverse health effects from the long-term chronic ingestion of untreated drinking water if the leachate migrates to drinking water supplies with only a tenfold dilution. The diluted concentration of arsenic in slag leachate could pose a cancer risk of greater than $1x10^{-5}$ from drinking water exposures.
- Concentrations of lead, copper, nickel, and zinc in leachate from the ferrosilicon could present a threat to aquatic organisms if the leachate enters a surface water and is diluted by a factor of 100.

Exhibit 14-5
Potential Constituents of Concern in Ferrosilicon Leachate[(a)]

Potential Constituents of Concern	Number of Times Constituent Dectected/ Number of Analyses for Constituent	Screening Criteria	Number of Analyses Exceeding Criteria/ Number of Analyses for Constituent
Lead	1 / 1	Human Health Resource Damage Aquatic Ecological	1 / 1 1 / 1 1 / 1
Manganese	1 / 1	Resource Damage	1 / 1
Copper	1 / 1	Aquatic Ecological	1 / 1
Nickel	1 / 1	Human Health Resource Damage Aquatic Ecological	1 / 1 1 / 1 1 / 1
Zinc	1 / 1	Resource Damage Aquatic Ecological	1 / 1 1 / 1
Selenium	1 / 1	Resource Damage	1 / 1
Iron	1 / 1	Resource Damage	1 / 1

(a) Constituents listed in this table are present in at least one sample from at least one facility at a concentration that exceeds a relevant screening criterion. The conservative screening criteria used in this analysis are listed in Exhibit 2-3. Constituents that were not detected in a given sample were assumed not to be present in the sample. The constituent concentrations used for this analysis are based on EP leach test results.

- Lead, manganese, nickel, zinc, selenium, and iron may be present in ferrosilicon leachate at concentrations that, if released to ground or surface water and diluted by a factor of 10 or less, potentially could exceed drinking water maximum contaminant levels and irrigation guidelines.

As explained for zinc slag, these exceedances do not demonstrate that ferrosilicon poses human health or environmental risks, but rather indicate that the waste could pose risks under a very conservative, hypothetical set of exposure conditions. To examine the potential hazards of ferrosilicon in greater detail, EPA proceeded to the next step of the risk assessment to evaluate the actual release, transport, and exposure conditions at the Monaca facility.

Release, Transport, and Exposure Potential

This analysis considers the baseline hazards of processed slag and ferrosilicon as they were managed at the Monaca plant in 1988:

- Processed zinc slag is stored in a waste pile and is used as drainage material in a flyash landfill. The slag pile covers an area of 1.2 hectares (3 acres) and is roughly 7 meters (23 feet) in height. The processed slag in the flyash landfill is approximately 0.3 meters deep and covers an area of 8 hectares.
- Ferrosilicon is accumulated in a pile that is approximately 7 meters (23 feet) high and has a basal area of 0.8 hectares (2 acres).

For this analysis, the Agency did not assess the hazards of off-site disposal or use of the wastes because neither waste is disposed off-site. Although a portion of the slag is sold for off-site use as road gravel or construction aggregate and there are plans to sell the ferrosilicon for use off-site as a source of iron, insufficient information is available to support a detailed analysis of the risks posed by these off-site operations. Existing and potential off-site management practices of these wastes, however, are discussed generally in Section 14.5. In addition, the following analysis does not consider the hazards associated with variations in waste management practices or potentially exposed populations in the future because of a lack of adequate information on which to base projections of future conditions.

Ground-Water Release, Transport, and Exposure Potential

The EPA and industry test data discussed above show that several constituents are capable of leaching from the processed zinc slag and ferrosilicon in concentrations that exceed the screening criteria. However, considering the existing waste management practices and neutral pH of the leachate, the only slag contaminants that are expected to be mobile in ground water if released are cadmium, arsenic, and selenium. The single ferrosilicon contaminant that is expected to be mobile in ground water is selenium.

The potential for these contaminants to be released to a useable aquifer and transported to exposure points is determined by a number of site-specific factors, such as the presence of engineered ground-water protection controls, depth to ground water, precipitation and net recharge, presence of intervening confining layers/aquifers, and the distance to down-gradient drinking water wells.

Because there are no liquids associated with the processed zinc slag as it exists in the waste pile or the landfill, there is no hydraulic head to drive the flow of contaminants from these management units. Similarly, no liquids are associated with ferrosilicon in its waste pile. Therefore, the potential for contaminants from these two wastes to leach into ground water is entirely dependent on the extent to which precipitation can infiltrate through the slag and into the ground. The annual precipitation at the location of this facility is relatively high (91 cm/year). Much of this precipitation is expected to infiltrate into ground water because the subsurface is generally quite permeable (i.e., net recharge at this location is a relatively high 25 cm/year). Thus, in the absence of engineered ground-water protection controls, leachate originating from the waste management units could seep into the ground. Useable ground water at the site, however, is relatively deep, approximately 24 meters beneath the units, and therefore somewhat protected from contamination.

The processed zinc slag pile and the ferrosilicon pile are not equipped with any engineered controls such as liners or leachate-collection systems to limit releases to ground water. However, the landfill in which zinc slag is used as a drainage material is underlain by in-situ clay and is equipped with a leachate collection system. Given these management controls and the hydrogeological characteristics of the area, the potential for processed zinc slag and ferrosilicon leachate to migrate from the waste piles to ground water is moderate to high. Slag leachate could also migrate from the landfill to ground water if the in-situ clay layer beneath the unit is discontinuous or the leachate collection system were to fail. However, monitoring at the facility indicates that drinking water standards have not been exceeded in the ground water. In addition, the concentration of some contaminants, most notably lead and zinc, in actual leachate is likely to be less than in the EP leachate because current disposal practices do not expose the wastes to sources of organic acids.

The aquifer beneath the facility currently supplies both drinking and commercial/industrial water. A drinking water well serving the Beaver County Home and Hospital is located very close to the facility (approximately 120 meters); however, this well appears to withdraw water from the deep useable aquifer and is unlikely to be significantly affected by the waste leachate. Thus, the potential for exposure is likely to be minimal. The Agency has no data on the presence of shallower ground water at this site, but considering the close proximity of the facility to the Ohio River, shallow ground water probably does exist. Any shallow ground water, however, is likely to discharge directly into the river and does not appear "useable."

Surface Water Release, Transport, and Exposure Potential

In theory, constituents of potential concern from processed zinc slag in the landfill and waste pile, as well as from the ferrosilicon in the waste pile, could enter surface waters by migration of leachate from the waste management units through ground water that discharges to surface water, or direct overland (stormwater) run-off of dissolved or suspended materials. As discussed above, the following constituents leach from the processed zinc slag and ferrosilicon under the conditions of the EP-toxicity test at levels above the screening criteria and are mobile in ground water: cadmium, arsenic, and selenium. Other constituents in the processed zinc slag and the ferrosilicon theoretically could pose a threat if they migrated into surface waters in the form of suspended particles.

The physical form of the processed zinc slag and the ferrosilicon should help limit the overland erosion of solids from the waste piles. The slag accumulated in the pile consists of particles of four sizes, typically ranging in size from approximately 0.2 to 7.5 cm while ferrosilicon accumulated in the waste pile consists of particles that are approximately 0.64 cm in size. Because only particles that are 0.1 mm or less in size tend to be appreciably erodible,[13] only a very small fraction of the zinc slag or ferrosilicon solids are likely to erode to any significant extent. The potential for stormwater run-off to carry both the erodible fraction of zinc slag and ferrosilicon and dissolved constituents from these wastes is high because the precipitation in this area is high (91 cm/year), the slope of the land is relatively steep (6 to 12 percent), and the waste pile lacks stormwater run-on/run-off controls to prevent surface erosion. Such routine releases are of less concern at the landfill because it is equipped with stormwater run-on/run-off controls (and because the slag is located in the subsurface drainage layer of this unit). Overland run-off could migrate to the Ohio River located a short distance away (60 meters) from the facility. Episodic overland releases to the river could also occur in a flood event because the facility is located in the 100-year floodplain. The moderate to high potential for release to ground water (as discussed above) could also release constituents of the two wastes to the river via discharge of contaminated ground water.

Although migration from the two waste piles and the landfill to the Ohio River are likely, any contaminants reaching the river would be diluted rapidly due to its very large flow (approximately 23,000 mgd). Therefore, migration of contaminants to the river could pose a moderate, but not high, risk to aquatic organisms and could moderately restrict possible future uses of the river (e.g., for drinking water supply). It should be noted that as far as the Agency knows, there are currently no intakes for drinking water or other consumptive uses of this river for at least 24 km (15 miles) downstream of the facility.

Air Release, Transport, and Exposure Potential

Because all of the constituents of potential concern are nonvolatile, zinc slag and ferrosilicon contaminants can only be released to air in the form of dust particles. The particles can be either blown into the air by wind or suspended in air by waste dumping and crushing operations. Factors that affect the potential for such airborne releases include the particle size of the slag and ferrosilicon, the height and exposed surface area of the waste piles, the number of days with precipitation that can suppress dust, the use of dust suppression controls, wind speeds, and the proximity of receptors to the Monaca facility. If airborne releases were to occur, chromium, nickel, and selenium in the zinc slag and ferrosilicon dust could pose a risk through the inhalation pathway.

In general, particles that are $\leq$ 100 micrometers (µm) in diameter are wind suspendable and transportable. Within this range, however, only particles that are $\leq$ 30 µm in diameter can be transported for considerable distances downwind, and only particles that are $\leq$ 10 µm in diameter are respirable. As mentioned previously, the smallest zinc slag particles are approximately 2 mm in diameter. The ferrosilicon particles are mostly approximately 6.4 cm in size, and furthermore, they are relatively heavy due to their high iron content. Therefore, the vast majority of the processed slag and ferrosilicon should not be suspendable, transportable, or respirable. It is likely that only a very small fraction of the slag and the ferrosilicon will be weathered and aged (or crushed) into smaller particles that can be suspended in air and cause airborne exposure and related impacts.

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[13] As indicated by the soil erodibility factor of the USDA's universal soil loss equation.

At Monaca, airborne releases from processed zinc slag in the landfill are not of concern because it is used as drainage material at the bottom of the unit. The processed zinc slag pile at this facility is relatively small (7 meters high and covers 1.2 hectares), as is the ferrosilicon pile (7 meters high and covers 0.3 hectares). Neither pile is covered with either vegetation or a synthetic material. Although the facility does not use any dust suppression controls, such as sprinkling water on the piles, the number of days with rain that may suppress dust is relatively large (119 days/yr). As a result, the surface of the two waste piles may be moist for almost a third of the time. While the Agency assumes that there are short term gusts of stronger winds, average wind speeds at Monaca range from 2.7 to 4.6 m/s, which are strong enough to produce wind erosion of any fine particles that may exist on the surface of the waste piles. Based on these factors, the potential for dusting is low at both waste piles. However, if particles are released from these waste management units, the potential for exposure is high because of the short distance to the nearest residence (90 meters), the relatively short distances to residences (180 meters to 670 meters) in directions with maximum wind frequency and wind speed, and the relatively large population within 1.6 km (958 people) and 8 km (approximately 52,000 people).

Proximity to Sensitive Environments

The Zinc Corporation of America facility is located in a 100-year floodplain, which indicates that large, episodic releases of contaminants in zinc slag and/or ferrosilicon could occur during large flood events. The dilution capacity of the Ohio River would be very high during these events, but a large washout could introduce a heavy load of zinc slag and ferrosilicon which could act as a source of contaminants for years to come.

Risk Modeling

Based on the preceding analysis of the intrinsic hazard of zinc slag wastes and the potential for the waste contaminants to be released into the environment, EPA ranked processed zinc slag and ferrosilicon as having a relatively high potential to pose a hazard to human health and the environment (compared to the other mineral processing wastes studied in this report). Therefore, the Agency used the model "Multimedia Soils" (MMSOILS) to estimate the ground-water, surface water, and air risks caused by the management of slag and ferrosilicon at the facility in Monaca, PA.

Ground-Water Risks

Using site-specific data with respect to contaminant concentrations, waste quantities, existing management practices, and hydrogeologic characteristics, EPA modeled potential releases to ground water from the processed slag and ferrosilicon piles at the Monaca facility. EPA considered in this analysis the potential releases of arsenic, cadmium, and selenium through the ground-water pathway based on the preceding analysis of processed slag and ferrosilicon leachate. In addition, the Agency modeled the risks caused by potential releases of lead to ground water, because lead concentrations measured in EP leach tests of both the slag and ferrosilicon exceeded the EP toxicity criterion.

The Agency's ground-water modeling results indicate that all four of these contaminants are likely to remain bound up in the unsaturated zone well beyond the modeling time frame considered (200 years). Once released from the base of the piles, EPA predicted that it would take arsenic, cadmium, and selenium 340 to 440 years to migrate through the unsaturated zone to the water table. EPA estimated that it would take over 10,000 years for any lead released from the piles to migrate to the water table. Therefore, the predicted risks associated with the release of these contaminants to the subsurface are effectively zero within the 200-year modeling horizon.

Surface Water Risks

To evaluate surface water risks, EPA estimated the concentrations of processed slag and ferrosilicon contaminants in the nearby Ohio River (located about 60 meters from the facility) after the contaminants have been fully mixed in the river's flow. EPA considered in this analysis the annual loading of contaminants to the river via ground-water seepage and erosion of small particles from the slag and ferrosilicon piles. The Agency predicted the surface water concentrations of the following constituents: arsenic, cadmium, copper, iron, lead, manganese, nickel, selenium, and zinc. For each constituent, the Agency compared the predicted concentrations to EPA-approved benchmarks for human health protection, drinking water maximum contaminant levels (MCLs), freshwater ambient water quality criteria (AWQC) for chronic exposures, and National Academy of Sciences recommended guidelines for irrigation and livestock waters.

Based on the Agency's modeling results, it appears that the very large average flow of the Ohio River near the Monaca site (23,000 mgd) is able to effectively assimilate chronic releases of contaminants from the processed zinc slag and ferrosilicon piles. EPA's predicted concentrations of each contaminant caused by releases from the slag and ferrosilicon were at least two orders of magnitude below the various criteria. This is true for predicted concentrations caused by releases from each waste independently, as well as total contaminant concentrations in the river resulting from aggregate releases from the two wastes. The predicted concentrations of arsenic, the only carcinogen modeled would pose a lifetime cancer risk of less than $2x10^{-9}$ (i.e., the chance of getting cancer would be less than two in one billion if the water was ingested over a 70-year lifetime). In every case, the contaminants were predicted to migrate to the Ohio River by run-off alone, not by seepage through ground water that discharges to the river.

Of the constituents that were modeled, only selenium is recognized as having the potential to biomagnify (concentrate in the tissues of organisms higher in the food chain). Even though the Agency predicted selenium concentrations that are well below the AWQC, there is a potential for selenium to biomagnify and cause adverse effects to wildlife at higher trophic levels. Cadmium, selenium, zinc, lead, and, to a lesser extent, arsenic can bioaccumulate in the tissue of freshwater fish that may be ingested by humans. However, even if an individual ingested 6.5 grams of fish[14] from the contaminated water every day of the year for 70 years, EPA estimates that cancer risks would be less than $1x10^{-9}$ and the doses of noncarcinogens would be below adverse effect thresholds.

Air Risks

EPA predicted the release of windblown dust from the processed slag and ferrosilicon piles, and the associated inhalation risks of the existing maximum exposed individual (located at a residence roughly 90 meters away in a south-southwest direction). EPA estimated the risks caused by windblown chromium, nickel, and selenium, through the inhalation pathway based on the preceding analysis of the wastes' composition. In general, the Agency's modeling approach was very conservative (i.e., tending to overpredict inhalation risks) because it was based on the assumption that there is an unlimited reservoir of fine particles that can be blown into the air from the zinc slag and ferrosilicon piles. As discussed previously, processed slag and ferrosilicon actually have limited wind erosion potential because the vast majority of the materials consists of large particles that are not suspendable or transportable in typical winds.

Even with this conservative approach, risks caused by the inhalation of dust from processed slag and ferrosilicon piles were predicted to be low. Specifically, at the residence of the maximum exposed individual, EPA predicted a total lifetime cancer risk of roughly $2x10^{-7}$ caused by the combined release of chromium and nickel from both wastes (the estimated inhalation risks caused by each waste individually were approximately the same, $8x10^{-8}$). Similarly, the predicted concentrations of selenium in air at the residence of the maximum exposed individual, caused by each waste individually and the two wastes together, were more than two orders of magnitude below the threshold concentration that could be associated with noncancer effects (dermatitis and gastrointestinal disturbances).

14.3.2 Damage Cases

State and EPA Regional files were reviewed in an effort to document the environmental performance of zinc slag waste management practices at the active Monaca, PA smelter and four inactive zinc smelters.[15] The inactive primary zinc smelters included facilities in Columbus, Ohio and El Paso, Texas, last operated by ASARCO and facilities in DePue, Illinois and Palmerton, Pennsylvania operated by Zinc Corporation of America (ZCA). The file reviews were combined with interviews with State and EPA regional regulatory staff. Through these case studies, EPA found that documented

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[14] This is a typical daily fish intake averaged over a year (EPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989).

[15] Facilities are considered inactive for purposes of this report if they are not currently engaged in primary mineral processing.

environmental damages associated with slag management had occurred at all three inactive smelters but not at the active facility.

ASARCO, Columbus, Ohio

The zinc smelter at Columbus, Ohio was owned by American Zinc Oxide from 1918 to 1970, at which time ASARCO purchased the property and operated it until ceasing production in 1986.[16,17] The facility produced zinc oxide from sphalerite ore by oxidation, reduction, and back oxidation.[18] Until recently, when ASARCO began selling its slag for further zinc recovery to Horsehead Resources,[19] it appears that all zinc slag was disposed and/or stored on-site. As of 1986, about 38,000 tons of zinc slag had been stored on the site in two primary slag piles: the northern pile, covering about 5 hectares (13 acres); and the southern pile, covering about 15 hectares (37 acres).[20,21]

Run-off from the facility drains to an open ditch near Joyce and 12th Avenues, referred to as the Joyce Ave. outfall. The receiving ditch, referred to as the American Ditch, flows about one mile through an industrial and residential area.[22,23] Until June 1989, when the American ditch was diverted to discharge directly to Alum Creek, flow from the American ditch entered the combined sewer of the city of Columbus.[24] Alum Creek, the present receiving stream, is classified as a primary contact, warm fishery, public, industrial, and agricultural water supply.[25]

In 1972, the City of Columbus found that its wastewater treatment facility was receiving excessive zinc and cadmium loadings from water originating at the ASARCO smelter site. Investigations eventually led to the conclusion that run-off and leachate from the on-site zinc slag were responsible for the excessive loading.[26] Water samples taken by the City of Columbus from the American Ditch, which bisects the facility, showed cadmium and zinc concentrations above limits established by the City. Dissolved cadmium measured 0.56 mg/L while dissolved zinc measures 92.0 mg/L; the recorded pH was 2.6.[27]

A 1981 analysis performed by the City of Columbus on ASARCO's discharge to the American Ditch showed that the discharge exceeded by several times the 3.0 mg/L City limit for zinc and that cadmium concentrations were also

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[16] City of Columbus. 1986. ASARCO Meeting. Representatives from Columbus Division of Sewerage and Drainage, Ohio EPA and ASARCO. October 30.

[17] Ohio Environmental Protection Agency. 1987. Inter-office communication from L. Korecko and C. Chao through W. McCarthy, CDO-DWPC, to R. Mehlhop, CDO-DWQMA, Re: Use Evaluation, Toxics Evaluation, Heavy Metals Allocation, etc. for ASARCO in Columbus. August 24.

[18] Ohio Department of Health. 1972. Untitled document concerning the history of the site and identification and solution of pollution problems. July 20.

[19] ASARCO. 1987. Letter from R. Marcus, Senior Environmental Scientist, to W. Schneider, Ohio EPA. January 30.

[20] City of Columbus, op. cit.

[21] ASARCO, op. cit.

[22] City of Columbus. 1981. Memorandum to R. C. Parkinson, Director of Public Service, through D.D. Robbins, Superintendent, from G. W. Newell, Manager of Surveillance, Re: American Ditch, ASARCO Pollution Problems. October 15.

[23] Ohio Environmental Protection Agency. 1981. Inter-Office Communication from K.A. Schultz, Chief, Emergency Response, to W.S. Nichols, Director, Re: "`Acid Ditch' Complaint." October 20.

[24] Ohio Environmental Protection Agency. 1989. Letter from D. R. Parkinson, Division of Water Pollution Control, Ohio EPA, to R. Marcus, Senior Environmental Scientist, ASARCO. September 22.

[25] Ohio Environmental Protection Agency. 1974. Briefing memo. April 2.

[26] Ohio Environmental Protection Agency. 1974. Briefing memo. April 2.

[27] Ohio Department of Health. 1972. Note from J. Shea (sic) to F. Klengalhafed (sic), Re: Water Samples taken by City of Columbus from the ASARCO stream on the company's property. August 3.

above the 0.5 mg/L City limit.[28] ASARCO was cited by the City for violations of discharge limits for cadmium and zinc into the sewer system.[29]

Slag area run-off sampling data for September and October, 1986 revealed zinc concentrations of 26 mg/L and 46 mg/L, respectively. At that time, ASARCO agreed to begin removing the zinc slag from the facility.[30] In August 1987, the Ohio EPA described the situation at this facility by stating that, "[d]ue to past practices over many years of dumping waste slag or clinker all over the site, there is still a problem with contaminated run-off. There are documented problems with high concentrations of zinc and cadmium in the run-off."[31] In November 1987, ASARCO notified the City of its shipment off-site of 35,000 tons of zinc slag.[32]

Recent testing has shown that the release of contaminants into surface waters has continued. An Ohio EPA inter-office communication from June 1988 included a report which stated that "overall analysis of cadmium and zinc concentrations from the Joyce Avenue outfall [ASARCO's discharge to the American Ditch] suggests acutely toxic conditions exist on a frequent basis." For zinc, twenty percent of water samples (5 percent for cadmium) taken from the ASARCO treatment center outfall were reported to have exceeded the Final Acute Value limits (188 µg/L for cadmium and 1,298 µg/L for zinc) established for American Ditch to protect against rapidly lethal conditions within a water body.

ASARCO, El Paso, Texas

This facility contains combined deposits of lead, copper, and zinc slag. Heavy metal contamination of surface water and sediment in the Rio Grande River has been linked to these slag deposits. This situation is more fully described in Section 6.3.4, Damage Cases, for the copper sector.

Zinc Corporation of America, DePue, Illinois

Zinc Corporation of America's (ZCA) Illinois zinc plant is located just east of the Illinois River and Lake DePue, in Bureau County. The facility was originally owned by New Jersey Zinc Company, Inc. which later changed its name to Zinc Corporation of America. Its parent company is Horsehead Resources. From 1905 until 1966, New Jersey Zinc operated a zinc smelter, sulfuric acid plant, phosphoric acid plant and diammonium phosphate plant at this facility. In 1966, Mobil Chemical Company purchased all plants except the zinc smelter, which ZCA operated until 1971. Currently, there are approximately 26 employees producing zinc dust from zinc scrap.[33,34,35]

Zinc smelting wastes were deposited in one pile at the southern end of the site that covers approximately 10 acres and ranges in height up to 50 feet. In addition, there are also a number of smaller piles on the site which measure approximately 100 feet in length and 10 to 12 feet in height. These smaller piles may contain zinc slag in addition to other

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[28] City of Columbus, 1981, op. cit.

[29] City of Columbus. 1981. Letter from R. C. Parkinson, Director, Department of Public Service, to N. S. Geist, Superintendent ASARCO. November 23.

[30] City of Columbus. 1986. ASARCO Meeting. Representatives from Columbus Division of Sewerage and Drainage, Ohio EPA and ASARCO. October 30.

[31] Ohio Environmental Protection Agency. August 24, 1987. Inter-office communication from L. Korecko and C. Chao through W. McCarthy, CDO-DWPC, to R. Mehlhop, CDO-DWQMA, Re: Use Evaluation, Toxics Evaluation, Heavy Metals Allocation, etc. for ASARCO in Columbus.

[32] The facility indicated that some slag (about 3,000 tons) had not been removed from the site due to possible PCB contamination resulting from a spill at an adjacent facility.

[33] Illinois Environmental Protection Agency. December 11, 1975. Letter from B.J. Revak to D.R. Baker, NJZ, Re: The New Jersey Zinc Company (Bureau Country), Illinois Environmental Protection Agency File #2794.

[34] Illinois Environmental Protection Agency. July 12, 1982. NPDES Permit No. IL0052183 for the New Jersey Zinc Company, Inc., DePue, Illinois.

[35] Illinois Pollution Control Board. April 7, 1988. Order of the Borad regarding Petition for Variance of Consent Order.

materials. Mobil Chemical Company did not purchase the land on which the slag piles are located and this property is still owned and controlled by Zinc Corporation of America.[36,37]

As early as 1967, the predecessor agency to the Illinois Environmental Protection Agency (EPA), the Illinois Sanitary Water Board, suspected rainfall run-off contamination from zinc slag piles located on New Jersey Zinc's property.[38] The Illinois EPA monitored the surface run-off and leachate from the zinc slag pile from 1973 to 1986. These analyses consistently showed levels of zinc, cadmium, copper, manganese, and lead in excess of the maximum contaminant levels for drinking water. For example, from March 5, 1973 to March 26, 1986, run-off samples which exceeded the established MCLs for drinking water from the slag pile ranged from 39 - 4000 mg/L for zinc (MCL = 5.0 mg/L); 0.5 - 3.6 mg/L for lead (MCL = .05 mg/L); 2.32 - 780 mg/L for manganese (MCL = 0.05 mg/L); 1.38 - 137.5 for copper (MCL = 1.3); and, 0.58 - 19.3 mg/L for cadmium (MCL = 0.01 mg/L). Run-off control measures (i.e., capping) have helped to reduce the levels of contaminant discharge. Surface water samples taken during April, May, and June of 1989 (after remedial controls were implemented at the facility) show the following range of concentration levels: zinc, 44.0 - 75.2 mg/L; lead, 0.05 - 0.06 mg/L; manganese, 1.8 - 3.83 mg/L; copper, 3.2 - 4.4 mg/L; and cadmium, 0.18 - .79 mg/L.[39,40,41,42,43,44]

Due to repeated problems in meeting effluent standards from this site, Zinc Corporation of America received a five-month discharge variance in April 1988, and a five-year extension to this variance in January 1989. Discharge monitoring reports submitted by the facility for the fourth quarter 1989 indicate that few surface water contamination problems remained.[45] Monitoring data on the quality of ground water beneath the slag piles were not available.

14.3.3 Findings Concerning the Hazards of Zinc Slag and Ferrosilicon

Based on a review of available data on the composition of processed zinc slag and ferrosilicon, the wastes have seven to ten constituents present in concentrations that exceed the risk screening criteria. The contaminants that appear to present the greatest potential for concern in the two wastes are chromium, lead, manganese, and copper. Zinc concentrations in the processed slag, but not the ferrosilicon, could also conceivably pose risk under mismanagement scenarios. Based on available data and professional judgment, EPA does not believe either of the wastes exhibit the hazardous waste characteristics of corrosivity, reactivity, or ignitability. Lead concentrations measured in leachate from both wastes using the EP test frequently exceed the EP toxicity regulatory level. Using the SPLP test, however, neither of the wastes exceeded the EP toxicity regulatory levels.

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[36] Illinois Environmental Protection Agency. December 11, 1975. Letter from B.J. Revak to D.R. Baker, NJZ, Re: The New Jersey Zinc Company (Bureau Country), Illinois Environmental Protection Agency File #2794.

[37] Illinois Pollution Control Board. op. cit.

[38] Illinois Environmental Protection Agency. May 12, 1977. Memorandum from D.P. Duffy to DWPC/FOS and Records Unit, Re: Mobil Chemical Company at DePue - Re: IL0032182 and New Jersey Zinc Company - IEPA File #2794.

[39] Illinois Environmental Protection Agency. March 5, 1973. Memorandum from L.W. Eastep to Division of Water Pollution Control, Surveillance Section, Re: New Jersey Zinc/Mobil Oil Company - Report of Operational Visit.

[40] Illinois Environmental Protection Agency. June 12, 1975. Memorandum from C.D. Miller to DQPC/FOS, Re: New Jersey Zinc - Mobil Chemical Company (DePue).

[41] Illinois Environmental Protection Agency. September 22, 1975. Memorandum from C.D. Miller to DWPC/FOS, Re: New Jersey Zinc - Sampling.

[42] Illinois Environmental Protection Agency. August 20, 1984. Memorandum from D.J. Connor to DWPC/FOS and Records Unit, Re: New Jersey Zinc - Sampling Visits.

[43] Illinois Environmental Protection Agency. June 9, 1986. Memorandum from D.J. Connor and H.J. Chien to DWPC/FOS and Records Unit, Re: New Jersey Zinc - Summary of findings.

[44] Horsehead Resources. July 21, 1989. Letter from D.P. Schoen to K. Rogers, Illinois Environmental Protection Agency, Re: Quarterly reports.

[45] Horsehead Resources. October 27, 1989. Letter from D.P. Schoen to K. Rogers, Illinois Environmental Protection Agency, Re: Quarterly reports.

Based on a review of existing waste management practices and predictive modeling results, EPA believes that processed zinc slag and ferrosilicon, as currently managed at the sole active zinc facility in Monaca, PA, pose an overall low risk to human health and the environment. The relatively high precipitation and ground-water recharge rates in Monaca, the permeable substrate, and the absence of liners or leachate collection systems combine to yield a high theoretical potential for contaminants to seep into the ground. However, the Agency predicts that metals leached from zinc slag and ferrosilicon at the Monaca facility would be largely bound to subsurface soil and would not reach ground water in the useable aquifer within 200 years. Similarly, there is a relatively high potential for slag and ferrosilicon contaminants to migrate into surface water because the facility is only 60 meters from the Ohio River, the annual precipitation is high, the slope of the land is relatively steep, and the waste management units lack stormwater run-off controls. The Ohio River, however, is very large and EPA predicts that it can readily assimilate the chronic loading of contaminants that is expected on a routine basis (the Agency's predicted annual average concentrations of contaminants in the river are at least two orders of magnitude below human health and environmental protection criteria). EPA's predicted concentrations of toxic constituents in the air caused by windblown dust from the waste management units also create very low risks at potential off-site exposure points.

The lack of documented cases of damage caused by the wastes at the Monaca facility supports the Agency's conclusion that zinc slag wastes at this facility pose a low risk. The two damage cases at inactive sites, however, demonstrate the potential for zinc slag to cause environmental problems when not managed properly. In particular, the damage cases demonstrate that the migration of contaminants from slag piles, especially contaminant migration via stormwater run-off, can cause surface water degradation when piles are maintained near small water bodies and not equipped with run-off controls.

14.4 Existing Federal and State Waste Management Controls

14.4.1 Federal Regulation

EPA is unaware of any federal management control or pollutant release requirements that apply specifically to zinc slag or ferrosilicon. EPA has promulgated effluent discharge limitations for the primary zinc smelting industrial category under authority of the Clean Water Act, but these regulations address wastewater discharges from wet air pollution control scrubbers and process sources, not slag storage or disposal (40 CFR 421). Federal air regulations applicable to zinc smelters apply to processing operations rather than waste management operations such as slag disposal.

14.4.2 State Regulation

The single zinc processing facility currently active in the United States that generates smelting slag is located in Monaca, Pennsylvania. Rather than regulating zinc slag as either a hazardous or solid waste, the state of Pennsylvania addresses zinc slag under its "residuals" regulations. Proposed revisions to the state's residuals regulations would require a substantial expansion in the scope of the management controls for zinc slag disposal. The proposed rule also would require that the owners/operators certify that they have attempted to reuse and/or recycle the waste before disposal, but apparently would not specify environmental controls for the reuse of the materials. The current residuals rule imposes only limited permitting requirements. For instance, although waste piles for permanent disposal must be permitted under current state residuals regulation, Pennsylvania effectively has not implemented this requirement for slag piles because of disagreements with industry on the status (i.e., storage versus disposal) of the piles. The state has not required that the Monaca plant obtain a permit for its slag piles. Similarly, the state applies surface water and air (i.e., fugitive dust control) requirements on a case-by-case basis and generally in response to complaints or evidence of environmental damage only. In summary, although the proposed residuals rule would impose notably more stringent environmental controls on the management of zinc slag than the state currently requires, the exact nature and extent of such controls cannot be predicted pending adoption and implementation of a final rule.

14.5 Waste Management Alternatives and Potential Utilization

The ZCA Monaca facility processes all of the slag emerging from the furnace (see section 14.2) to isolate those portions that can be returned to the production process or otherwise utilized. The slag is separated into four materials: reclaimed coke and zinc-rich fines, which are both recycled; ferrosilicon, which is stockpiled until it can be sold to cast iron manufacturers; and processed slag, which may be disposed in a slag pile or used is the facility's flyash landfill or in construction applications.

14.5.1 Waste Management Alternatives

The amount of zinc slag that is recycled can vary, depending on the amount of zinc and coke contained in the slag. The amount of zinc and coke in the slag is largely a function of how efficiently the retort furnace utilizes the feed materials, and the nature and quality of the ore and secondary materials being fed to the smelting process. Both the retort furnace efficiency and feed materials can vary considerably from run to run, and the facility adjusts the amount of zinc slag being returned to the process to extract the maximum amount of zinc from the inputs (96-97 percent).[46] Consequently, there is little potential for further reducing the amounts of waste slag being generated by increasing recycling efforts.

14.5.2 Utilization

In 1988, 17,000 and 28,000 metric tons of ferrosilicon and processed slag, respectively, which were separated from the slag removed from the furnace, were sent to on-site storage/disposal piles. During the same period, however, 32,500 metric tons of processed slag were removed from the slag piles for utilization. While none of the ferrosilicon was sold in 1988, sales before and after 1988 have been reported.[47] This information, along with the relatively small on-site accumulations of ferrosilicon (48,000 metric tons) and processed slag (63,500 metric tons) suggest that much of the zinc slag that cannot be recycled is being utilized in the ways discussed below.

Utilization of Ferrosilicon to Produce Cast Iron

The ferrosilicon, which is magnetically separated from the rest of the zinc slag, is occasionally sold to cast iron foundries as a source of iron. The amount of ferrosilicon sold to produce cast iron is largely a function of the technical requirements of the cast iron producers and the relative prices of ferrosilicon and scrap steel (competing materials). The 1988 slump in sales of ferrosilicon are attributed to the ferrosilicon being over-priced. ZCA has since lowered the price of ferrosilicon and sales have increased.[48]

Utilization of Processed Slag as Drainage Material in Landfills

The processed slag is currently being used as a drainage material in the flyash landfill at the Monaca facility. The flyash is generated by two 60 megawatt power plants that are located on-site and produce power for the facility. The processed slag has been placed in a layer on the bottom of the flyash landfill and covered with fabric (to prevent clogging by the flyash) before any flyash is added. In 1988, the facility used 27,000 metric tons of its processed slag in this fashion. ZCA also uses the two medium-sized fractions of processed slag as a cover material to reduce dust from the flyash landfill. This practice was only recently begun, however, so it has not yet been determined how much slag will be used in this way.

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[46] Personal communication, James D. Reese, Director of Environmental Affairs, Zinc Corporation of America, April 20, 1990.

[47] Ibid.

[48] Ibid.

The use of processed zinc slag as a drainage material in flyash landfills should be at least as protective of human health and the environment as disposing it in a slag pile. If the water captured by the leachate collection system is treated to remove any constituents of concern or the slag serves to remove contaminants from any flyash leachate, this practice should prove to be more protective of human health and the environment than disposal in one of the slag piles (which do not have leachate collection/treatment systems).

Processed Slag as Railroad Ballast and Road Rock

Zinc slag from the Monaca facility has also been utilized as railroad ballast and road rock (gravel).[49,50,51] Approximately 23,900 metric tons of zinc slag were sold as railroad ballast in 1982 and 5,500 metric tons of processed slag were sold as gravel for roads, driveways, and parking lots in 1988.[52,53] No information has been found to indicate that future levels of use will greatly exceed the current 5,500 metric tons per year. It should be noted that only the two medium-sized fractions of processed slag are of the preferred size for these applications.

With one exception, EPA believes that the use of processed slag as railroad ballast or road rock poses risks comparable to those stemming from its disposal in slag piles. The exception is that use as road rock will increase the potential for airborne releases of slag dust. The basis for this belief is that when the slag is used on roads or driveways, it will be in closer proximity to people, and will also be subjected to crushing and dust entrainment by passing vehicles. EPA does not, however, have sufficient information to determine whether this is a significant concern.

Utilization as an Aggregate in Asphalt Manufacturing

Processed zinc slag has been used as an aggregate in asphalt and as an anti-skid material, though tests performed at Oklahoma State University on four types of zinc smelter slag indicate that it is not suitable for use as an aggregate in portland cement concrete because of alkali-aggregate activity.[54] ZCA reported that while none of its processed slag is currently being sold as aggregate for asphalt, the technical suitability of and markets for the material are being investigated.[55]

It is not expected that using processed zinc slag as an aggregate in asphalt will alter the chemical composition of the slag, but the potential for any of the slag constituents to enter the environment via leachate or dust is expected to be less than for use as road rock or disposal in a slag pile.

14.6 Cost and Economic Impacts

Section 8002(p) of RCRA directs EPA to examine the costs of alternative practices for the management of the special wastes considered in this report. EPA has responded to this requirement by evaluating the operational changes that would be implied by compliance with three different regulatory scenarios, as described in Chapter 2. In reviewing and evaluating the Agency's estimates of the cost and economic impacts associated with these changes, it is important to remember what the regulatory scenarios imply, and what assumptions have been made in conducting the analysis.

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[49] PEI Associates, Inc., 1984. Overview of Solid Waste Generation, Management, and Chemical Characteristics: Primary Zinc Smelting and Refining, prepared for U.S. Environmental Protection Agency, Office of Reaserch and Development, Cincinnati, Ohio, Contract No. 68-03-3197, Work Assignment No. 3.

[50] Zinc Corporation of America, 1989(a), op. cit.

[51] Reese, op. cit.

[52] PEI Associates, Inc., op. cit.

[53] Zinc Corporation of America response to EPA, 1989(a), op. cit.

[54] Collins, R.J. and R.H. Miller, Availability of Mining Wastes and Their Potential for Use as Highway Material - Volume I: Classification and Technical and Environmental Analysis, FHWA-RD-76-106, prepared for Federal Highway Administration, May 1976, pp. 168-170, 178, 196, and 210.

[55] Reese, op. cit.

The focus of the Subtitle C compliance scenario is on the costs of constructing and operating hazardous waste land disposal units. Other important aspects of the Subtitle C system (e.g., corrective action, prospective land disposal restrictions) have not been explicitly factored into the cost analysis. Therefore, differences between the costs estimated for Subtitle C compliance and those under other scenarios (particularly Subtitle C-Minus) are less than they might be under an alternative set of conditions (e.g., if land disposal restrictions had been promulgated for "newly identified" hazardous wastes). The Subtitle C-Minus scenario represents, as discussed above in Chapter 2, requirements that might apply to any of the special wastes that are ultimately regulated as hazardous wastes; this scenario does not reflect any actual determinations or preliminary judgments concerning the specific requirements that would apply to any such wastes. Further, the Subtitle D-Plus scenario represents one of many possible approaches to a Subtitle D program for special mineral processing wastes, and has been included in this report only for illustrative purposes. The cost estimates provided below for the three scenarios considered in this report must be interpreted accordingly.

In accordance with the spirit of RCRA §8002(p), EPA has focused its analysis on impacts on the firms and facilities generating the special wastes, rather than on net impacts to society in the aggregate. Therefore, the cost analysis has been conducted on an after-tax basis, using a discount rate based on a previously developed estimate of the weighted-average cost of capital to U.S. industrial firms (9.49 percent), as discussed in Chapter 2. Waste generation rate estimates (which are directly proportional to costs) for the period of analysis (the present through 1995) have been developed in consultation with the U.S. Bureau of Mines.

In this section, EPA first outlines the way in which it has identified and evaluated the waste management practices that would be employed by the affected primary zinc producer under different regulatory scenarios. Next, the Agency discussed the cost implications of requiring these changes to existing waste management practices. The last part of this section predicts and discusses the ultimate impacts of the increased waste management costs faced by the affected zinc facility.

14.6.1 Regulatory Scenarios and Required Management Practices

Based upon the information presented earlier in this chapter, EPA believes that zinc slag poses an overall low risk to human health and the environment. Nonetheless, the special waste exhibits the hazardous waste characteristic of EP toxicity. Accordingly, the Agency has estimated the costs associated with regulation under Subtitle C of RCRA, as well as with two somewhat less stringent regulatory scenarios, referred to here as "Subtitle C-Minus" and "Subtitle D-Plus," as previously introduced in Chapter 2, and as described in specific detail below. The Agency's cost and impact analysis is limited to the single pyrometallurgical primary zinc processor, the ZCA facility in Monaca, Pennsylvania.

In the following paragraphs, EPA discusses the assumed management practices that would occur under each regulatory alternative.

Subtitle C

Under Subtitle C standards, hazardous waste that is managed on-site must meet the standards codified at 40 CFR Part 264 for hazardous waste treatment, storage, and disposal facilities. Because zinc slag and its residues are solid, non-combustible materials, and because under full Subtitle C regulation, hazardous wastes cannot be permanently disposed in waste piles, EPA has assumed in this analysis that the ultimate disposition of processed zinc slag and ferrosilicon would be in Subtitle C landfills. Because, however, current practice at the Monaca facility is storage and/or disposal of these materials in waste piles, the Agency has assumed that the facility would also construct a temporary storage waste pile (with capacity of one week's waste generation) that would enable the operators to send the processed slag and ferrosilicon to on-site disposal efficiently. EPA has assumed that the Monaca plant could not continue to sell or utilize the ferrosilicon and processed slag as it does currently, and would dispose the total quantities of these materials in a lined landfill. EPA believes that, because of cost considerations, ZCA would construct one on-site landfill that meets the minimum technology standards specified at 40 CFR 264, rather than ship the material off-site to a commercial hazardous waste landfill or build multiple landfills.

Subtitle C-Minus

A primary difference between full Subtitle C and Subtitle C-minus is the facility-specific application of requirements based on potential risk from the hazardous special waste. Under the C-minus scenario, as well as the Subtitle D-Plus scenario described below, the degree of potential risk of contaminating groundwater resources was used as a decision criterion in determining what level of protection (e.g., liner and closure cap requirements) would be necessary to protect human health and the environment. The Monaca facility was determined to have a low potential to contaminate groundwater resources. Therefore, under the Subtitle C-Minus scenario, the facility would be allowed to continue to operate its present storage waste piles, though run-on/run-off and wind dispersal/dust suppression controls are assumed to be required for the units. In addition, the storage units must undergo formal closure; they are assumed to be "clean closed" with all inventory removed.

While under baseline conditions the ultimate disposition of processed slag and ferrosilicon is periodic sale for utilization (i.e., not recycling); under this regulatory scenario EPA has assumed that neither material could be utilized in this way due to its intrinsic hazardous waste characteristics. Therefore, the facility is assumed to be required to operate a disposal waste pile. Because the facility is located in a low risk area, the unit would not require a liner and could be capped with a simple revegetated soil layer at closure. Run-on/run-off controls and groundwater monitoring would be required; both practices would continue during the 30 year post-closure care period.

Subtitle D-Plus

As under both Subtitle C scenarios, the facility operator would, under the Subtitle D-plus scenario, be required to ensure that hazardous contaminants do not escape into the environment. Like the Subtitle C-Minus scenario, facility-specific requirements are applied to allow the level of protection to increase as the potential risk to ground water increases. As the Monaca facility has low potential to contaminate ground-water resources, the facility is assumed to be allowed to continue operating its storage waste piles under the Subtitle D-Plus scenario. The waste piles would be retrofitted with run-on/run-off and wind dispersal/dust suppression controls which, as under Subtitle C-Minus, must be maintained through closure and the post-closure care period. While under baseline the ultimate disposition of ferrosilicon was sale for off-site utilization (i.e., not recycling), under the Subtitle D-Plus regulatory scenario the waste (with its intrinsic hazard) could not be sold for off-site use. Therefore, the facility is assumed to be required to operate a waste pile for disposal of the ferrosilicon. As the unit is located in a low risk area, this disposal waste pile would not require a liner; ground-water monitoring and capping at closure is assumed to not be required for management units under Subtitle D-Plus when the ground-water contamination potential is low, although wind dispersal/dust suppression controls must be maintained.

14.6.2 Cost Impact Assessment Results

Results of the cost impact analysis for the Monaca zinc smelter are presented for each regulatory scenario in Exhibit 14-6

. Under the full Subtitle C scenario, ZCA's annualized regulatory compliance costs are estimated to be just under $5 million more than the baseline waste management costs (about 195 times greater). Two thirds ($3.2 million) of the increased compliance costs would be for new capital expenditures.

Under the facility specific risk-related requirements of the Subtitle C-Minus scenario, costs of regulatory compliance are, for the sector, about 72 percent less than the full Subtitle C costs. ZCA's annualized compliance costs would be $1.4 million more than the baseline waste management costs (about 55 times greater). The primary savings over the full Subtitle C costs, due to the consideration of risk potential, are the relaxation of technical requirements and the ability to use disposal wastepiles. New capital expenditures, nearly 83 percent less than under full Subtitle C, would account for about $555,000 of the incremental C-Minus compliance costs (about 40 percent of the annualized compliance cost).

Regulation under the Subtitle D-Plus program is assumed to require the same management controls as under Subtitle C-minus, with the exception that, because of the low risk classification, no ground-water monitoring or capping at closure is required under this scenario. ZCA's annualized regulatory compliance costs would be $1.1 million more than the baseline waste management costs. This represents an increase of about 42 times over baseline, but a decrease of 78 percent from the Subtitle C compliance costs, and a decrease of 23 percent from estimated Subtitle C-Minus compliance costs.

14.6.3 Financial and Economic Impact Assessment

To evaluate the ability of the affected facility to bear these regulatory compliance costs, EPA conducted an impact assessment consisting of three steps. First, the Agency compared the estimated costs to several measures of the financial strength of the facility (in the form of financial impact ratios) to assess the magnitude of the financial burden that would be imposed in the absence of changes in supply, demand, or price. Next, in order to determine whether compliance costs could be distributed to (shared among) other production input and product markets, EPA conducted a qualitative evaluation of the salient market factors that affect the competitive position of domestic primary producers of zinc. Finally, the Agency combined the results of the first two steps to arrive at predicted ultimate compliance-related economic impacts which would have to be absorbed by ZCA. The methods and assumptions used to conduct this analysis are described in Chapter 2 and in Appendix E-4 to this document.

Financial Ratio Analysis

Screening analysis of the financial ratios indicates that regulation of zinc slag under full Subtitle C would have a potentially significant financial impact on the ZCA facility. As shown in Exhibit 14-7, annualized compliance costs exceed five percent of value of shipments and eleven percent of value added. Annualized compliance capital represents a full 45 percent of the average sustaining capital needed annually.

Under the Subtitle C-Minus and D-Plus scenarios, impacts are substantially less and only marginally significant. Annual compliance costs as a percent of value of shipments is less than 1.5 percent under either scenario; the percent of those costs to value added are 2-3 percent under the two scenarios. Under both scenarios the annualized compliance capital is between 7 and 8 percent of the annual sustaining capital investments.

Market Factor Analysis

General Competitive Position

In 1987, a total of 342,663 metric tons of slab zinc was produced by the four domestic zinc-producing facilities; three facilities (which do not produce a special waste) used the electrolytic technique, and one facility (ZCA-Monaca, which produces a special waste) used the pyrometallurgical technique. Domestic metal production in 1988 was near annual capacity (approximately 400,000 metric tons). Strong demand and high prices are expected to result in growth rates throughout the 1990's of 0-2.5 percent in the U.S., and greater than 2.5 percent globally. The opening of one zinc mine in Idaho and the anticipated opening of two more in Alaska are an indication that domestic zinc mine output will remain high. Secondary production has increased steadily over the past five years from a low of 63,000 metric tons to an estimated 110,000 metric tons in 1989; this sub-sector is expected to continue to meet a large portion of the domestic demand for zinc.

Domestic zinc consumption in 1988 rose in virtually all use categories, led by increases in galvanizing and electro-galvanizing, and resulted in record-high imports of both slab zinc and zinc oxide. Both domestic and global consumption of zinc are expected grow more than 2.5 percent per year throughout the 1990's.

Exhibit 14-7
Significance of Regulatory Compliance Costs for Management of Zinc Slag from Primary Processing[a]

Facility	CC/VOS	CC/VA	IR/K
Subtitle C			
Zinc Corporation of America - Monaca, PA	5.1%	11.4%	45.4%
Subtitle C-Minus			
Zinc Corporation of America - Monaca, PA	1.4%	3.2%	7.7%
Subtitle D-Plus			
Zinc Corporation of America - Monaca, PA	1.1%	2.4%	7.2%

CC/VOS	=	Compliance Costs as Percent of Sales
CC/VA	=	Compliance Costs as Percent of Value Added
IR/K	=	Annualized Capital Investment Requirements as Percent of Current Capital Outlays
(a)	Values reported in this table are based on EPA's compliance cost estimates. The Agency believes that these values are precise to two significant figures.	

Potential for Compliance Cost Pass-through

Labor Markets. Approximately 2,100 people are employed in the mining and milling of zinc, and 1,500 people are employed in primary zinc smelting. No other information is currently available.

Lower Prices to Suppliers. While it may be possible to pass along a portion of increased costs to suppliers, the partial integration of the zinc producers and zinc ore mines make it unlikely that very much of the cost could be passed backwards.

Higher Prices. U.S. "High Grade" zinc currently costs about 5 cents more than its "Prime Western" equivalent, indicating that an increase in U.S. prices would be infeasible without an equivalent rise in the world price of zinc. However, with the currently tight supply-demand situation, world reserves of zinc have fallen, resulting in record-high prices during the last quarter of 1988. Therefore, it appears that any affected U.S. companies might be able to pass on somewhat higher costs in the form of higher prices if current consumption trends continue.

Evaluation of Cost/Economic Impacts

Given the severe cost impacts which would be experienced by ZCA under full Subtitle C, and the limited potential for long-term compliance cost pass-through, EPA believes that regulation of zinc slag under full Subtitle C regulations would pose a threat to the economic viability of the ZCA facility. The estimated compliance costs represent significant portions of the value added by zinc processing operations at the Monaca plant, would be expected to exceed ZCA's operating margins, and would likely force ZCA to discontinue operating the Monaca facility, at least as a primary zinc smelter.

Prospective impacts under Subtitle C-Minus regulation and, to a greater extent, under D-Plus regulation, would be marginally significant at worst, as demonstrated by the results of the financial ratio screening analysis. In addition, ZCA occupies a unique market niche as the only primary zinc processor with smelter operations that can utilize scrap and other secondary materials which are not readily recoverable in electrolytic zinc plants, as feedstocks, and ZCA/Monaca's upgraded energy efficient electrothermic furnaces (installed in 1980) have served to lower production costs in recent years. Therefore, EPA believes that the facility would be able to incur the estimated costs and continue operating in the currently strong zinc market. If current zinc prices remain strong, ZCA might be able to raise prices sufficiently to offset some or all of its compliance costs, at least in the short term. As an alternative, ZCA might also further process its ferrosilicon in order to reduce its potential toxicity, thereby allowing sale for reprocessing. As a final option, ZCA could adopt the practices of other smelter operations and shift to secondary processing, thereby decreasing or eliminating the fraction of ore comprising its feedstock, and, presumably, reducing the generation rate of its slag. In any case, EPA expects that regulation under the Subtitle C-Minus or D-Plus regulatory scenarios would not significantly affect the facility or threaten its continued economic viability.

14.7 Summary

As discussed in Chapter 2, EPA developed a step-wise process for considering the information collected in response to the RCRA §8002(p) study factors. This process has enabled the Agency to condense the information presented in the previous six sections of this chapter into three basic categories. For each special waste, these categories address the following three major topics: (1) potential for and documented danger to human health and the environment; (2) the need for and desirability of additional regulation; and (3) the costs and impacts of potential Subtitle C regulation.

Potential and Documented Danger to Human Health and the Environment

The intrinsic hazard of processed slag and ferrosilicon from zinc processing is relatively high compared to other mineral processing wastes studied in this report. Based on EP leach test results, 25 out of 36 samples of processed slag and 1 out of 1 sample of ferrosilicon from the Monaca facility contain lead concentrations in excess of the EP toxicity regulatory levels. Lead concentrations measured in SPLP (EPA Method 1312) leachate, however, were well below the EP regulatory levels. In addition, processed zinc slag contains five constituents in concentrations that exceed the conservative screening criteria used in this analysis by more than a factor of 10. Ferrosilicon contains four constituents in concentrations greater than 10 times the conservative screening criteria.

Based on a review of existing waste management practices and predictive modeling results, EPA believes that processed zinc slag and ferrosilicon, as currently managed at the active zinc facility in Monaca, PA, pose an overall low risk to human health and the environment. The relatively high precipitation and ground-water recharge rates in Monaca, the permeable substrate, and the absence of liners or leachate collection systems combine to yield a high theoretical potential for contaminants to seep into the ground. However, the Agency predicts that metals leached from zinc slag and ferrosilicon at the Monaca facility would be largely bound to subsurface soil and would not reach ground water in the useable aquifer within 200 years. Similarly, there is a relatively high potential for slag and ferrosilicon contaminants to migrate into surface water because the facility is only 60 meters from the Ohio River, the annual precipitation is high, the slope of the land is relatively steep, and the waste management units lack stormwater run-off controls. The Ohio River, however, is very large and EPA predicts that it can readily assimilate the chronic loading of contaminants that is expected on a routine basis (the Agency's predicted annual average concentrations of contaminants in the river are at least two orders of magnitude below human health and environmental protection criteria). EPA's predicted concentrations of toxic constituents in the air caused by windblown dust from the waste management units also create very low risks at potential off-site exposure points.

The lack of documented cases of damage caused by the wastes at the Monaca facility supports the Agency's conclusion that zinc slag wastes managed at this facility pose a low risk. The damage cases at inactive sites, however, demonstrate the potential for zinc slag to cause environmental problems when not managed properly. In particular, the damage cases demonstrate that the migration of contaminants from slag piles, especially contaminant migration via stormwater run-off, may cause significant surface water degradation when piles are maintained near small water bodies and not equipped with run-off controls. (Although some of the management units at the Monaca Plant are not equipped with run-off controls, surface water impacts are limited by the large flow of the Ohio River.)

Likelihood That Existing Risks/Impacts Will Continue in the Absence of Subtitle C Regulation

Although zinc slag wastes are expected to maintain a relatively high intrinsic hazard in the future, the waste management practices and environmental conditions that currently limit the potential for significant threats to human health and the environment at the Monaca facility are expected to continue to limit risks in the future in the absence of Subtitle C regulation. The characteristics of these wastes are unlikely to change in the future, and no new zinc smelters that would produce these wastes are expected to commence operation in the near future. A portion of the zinc slag is sold for use at off-site locations as road gravel or construction aggregate, and ferrosilicon is stockpiled until it can be sold for off-site use as a source of iron. Because these off-site locations could be conducive to releases and risks at present and in the future, this analysis of the potential and documented dangers of these wastes at the Monaca facility may underestimate the risks associated with these wastes at other locations. EPA is concerned that some types of slag and ferrosilicon utilization may not be protective of human health and the environment and plans to investigate methods to ensure that all slag uses are protective.

At this time, Pennsylvania does not regulate zinc slag wastes as either hazardous or solid wastes. Rather, the state addresses zinc slag under its "residuals" regulations. The current residuals rule imposes only limited permitting requirements, and the state has not required that the Monaca facility obtain a permit for its slag piles. Moreover, the State applies surface water and fugitive dust control requirements on a case-by-case basis and generally only in response to complaints or evidence of environmental damage. Proposed revisions to the state's residuals rule, however, would require a substantial expansion in the scope of the management controls for zinc slag disposal. The revised rule also would require that the owners/operators certify that they have attempted to reuse and/or recycle the waste before disposal, but apparently would not specify environmental controls for the reuse of the materials. It is not clear at this time how the rule may address inactive or abandoned units.

Costs and Impacts of Subtitle C Regulation

Because EPA waste sampling data indicate that processed slag and ferrosiliicon from the Monaca facility may exhibit the hazardous waste characteristic of EP toxicity, the Agency has evaluated the costs and associated impacts of regulating these materials as hazardous wastes under RCRA Subtitle C. As with the other aspects of this study, the Agency's cost and impact analysis is limited in scope to the facility at Monaca, PA.

Costs of regulatory compliance approach $5 million annually under the full Subtitle C regulatory scenario, while regulation under the more flexible standards of the Subtitle C-Minus scenario imply compliance costs of about $1.4 million annually, a reduction of 72 percent over full Subtitle C costs. Incremental costs under the Subtitle D-Plus scenario are just over $1 million annually. Subtitle C costs represent a significant fraction (more than eleven percent) of the value added by the Monaca operation, and would require capital expenditures exceeding 45 percent of the annual capital currently required to sustain production at this facility. Estimated Subtitle C-Minus and Subtitle D-Plus costs are estimated from one to three percent of the value of shipments of and value added by the facility. EPA's economic impact analysis suggests that the operator of the potentially affected facility (ZCA) would have only a limited ability to pass through a portion of any regulatory compliance costs that it might incur to product consumers, because of competition from other, unaffected zinc producers, both domestic and foreign. Because of these factors, EPA believes that a decision to regulate slag from primary zinc production under RCRA Subtitle C could adversely affect the ability of the Monaca facility to continue to compete successfully over the long-term, while the estimated costs associated with the Subtitle C-Minus and D-Plus scenarios are not likley to result in significant impacts.

Finally, EPA believes that incentives for recycling or utilization of zinc slag would be mixed if a change in the regulatory status of this waste were to occur. In-process recycling is the current managment practice that is applied to zinc slag. It is possible that tighter regulatory controls on the management of primary zinc slag and its residues might serve to promote even greater recycling and on-site utilization than has occurred in the recent past. Utilization of processed zinc slag in construction and other off-site applications has been reported, but is not widely practiced at present, while utilization of ferrosilicon as a feedstock for producing cast iron by foundries has been occurring for some time. It is likely that removing zinc slag from the Mining Waste Exclusion and thereby subjecting it to regulation as a hazardous waste would, in practical terms, eliminate the off-site use of processed slag in construction applications, and of ferrosilicon as a source of iron in cast iron foundries.

Exhibit 14-6
Compliance Cost Analysis Results for Management of Zinc Slag from Primary Processing[a]

Facility	Baseline Waste Management Cost	Incremental Costs of Regulatory Compliance								
		Subtitle C			Subtitle C-Minus			Subtitle D-Plus		
	Annual Total ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)	Annual Total ($ 000)	Total Capital ($ 000)	Annual Capital ($ 000)
Zinc Corporation of America - Monaca, PA	25	4,922	21,978	3,279	1,377	3,717	555	1,058	3,467	517
Total:	25	4,922	21,978	3,279	1,377	3,717	555	1,058	3,467	517

(a) Values reported in this table are those computed by EPA's cost estimating model, and are included for illustrative purposes. The data, assumptions, and computational methods underlying these values are such that EPA believes that the compliance cost estimates reported here are precise to two significant figures.